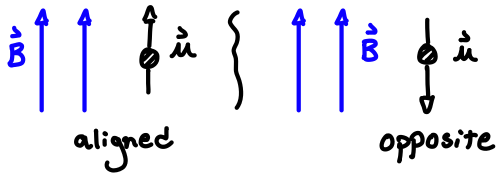
1-21-20

Statistical and Thermal Physics

- system where there is a large number of individual constituents
- e.g. 1) gas consisting of molecules
  2) collection of spin-½ particles

Example: gas
- rather than describe motion of individual particles use "bulk" variables
  Pressure, Temp, Volume, ...

Example: collection of spin-1/2 systems
- Single spin-½ - has magnetic dipole moment → vector $\vec{\mu}$
- in field



Can track magnetization : $\vec{M} = \Sigma$ individual dipole moments $\vec{\mu}$

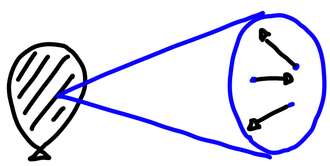
Thermodynamics

- general framework for relating bulk variables in such systems
- two crucial quantities:
  energy E
  entropy S
- general rules:
  e.g. temp
  $$\frac{1}{T} = \frac{\partial S}{\partial E}$$

applications:
- chemistry
- solid state physics
- astrophysics

Statistical Physics

- consider microscopic properties of system
- how to get thermodynamic rules
  e.g. $PV = NkT$

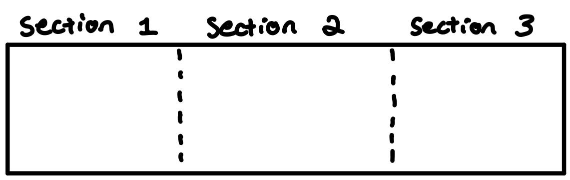


Describe state of particles using basic classical or quantum physics. position, velocity

List possible states of system and provide rules for the probability with which each state occurs
Averaging and other statistical techniques give bulk quantities

Toy Models

- illustrate basic ideas via very simplified model
- e.g. particles in a box with subdivisions
- add N particles, shake
- then : n_j = number in section j , note : $N = n_1 + n_2 + n_3$
  N = total number



Can ask:

1) after many interactions between particles does n_1 approach a fixed value? What? What about n_2?
2) is there some sort of "equilibrium state"?

Work Sheet

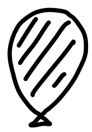
a.) Around 90 in each
b.) Not fixed, around 90
c.)

t	n_1	n_2	n_3
2	54	158	58
10	87	106	77
20	83	99	88

	$\bar{n}_1$	$\bar{n}_2$	$\bar{n}_3$
Avg. 20-40	84	96	90
Avg. 40-60	88.6	93.3	88.1

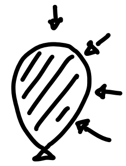
Thermodynamics: overview

- describe a system via bulk variables.
- example: gas



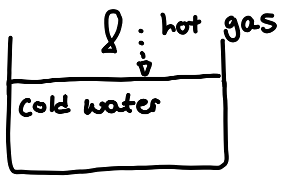
- type of gas (e.g. ideal)
- variables: P, V, T, N, E ....

1.) Describe system + states via bulk variables
2.) Relate the variables via "equations of state"
3.) Consider processes that change state of gas. Describe via energy
4.) Describe processes that are possible for interacting systems



Compress

$\Delta E = Q + W$
First law of thermodyn.



Entropy
$\Delta S \geq 0$
Second law of thermodyn.

States of a System

List variables that describe possible states
and
A particular state is decribe by giving values to variables

e.g. gas
N = number of particles
V = volume of gas (m^3)
P = pressure of gas (Pa) → Force per area → same everywher
T = temperature (K) → Thermometer? → math definition?